Transportation Planning, Execution, and Freight Payment Managers and Related Methods

CROSS REFERENCE TO RELATED APPLICATION

5   This application claims priority from U.S. Provisional Patent Application Serial No. 60/212,124, filed June 16, 2000, the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

10   The present invention relates to a transport manager and related method for determining an optimal, cost-minimizing set of product transportation decisions based upon expected transportation costs. In addition, the invention further

15 relates to an electronic transportation plan execution and freight payment managers and related method for tracking and controlling the delivery and/or pickup of products according to an optimized transportation plan as well as forwarding payments and invoices for the transport of the products.

BACKGROUND OF THE INVENTION

20   Within the modern economy, the transportation of goods and products is increasingly critical to the success of an organization. For example, businesses that operate on the Internet typically must transport goods to customers with every order. For these Internet business, transportation is

25 not merely a simple business function that must be managed, but rather a strategic function that influences revenue generation and customer satisfaction. More specifically, a business having relatively higher transportation costs and/or relatively slower or less reliable delivery of goods may be at

30 a severe competitive disadvantage. Accordingly, many

1

organizations devote a high level of logistic resources to managing the transportation of goods and products, and, depending on the industry, the management of transportation services may account for up to half of an organization's total

5   logistics cost.

Organizations have traditionally relied on one or more workers, hereafter transportation planning managers, to make decisions related to the transportation of goods and services. The transportation planning managers typically decide when,

10   where, and how to transport goods and products. For instance, the transportation planning managers may determine the method or combination of methods of transport, namely air, freight, truck, cargo ships, etc., based upon business needs and the costs for transportation. As part of this determination, the

15   transportation planning managers may also need to decide routes and times for transportation. The transportation planning managers may further decide the optimal packaging configuration (e.g., a few larger packages versus numerous smaller packages). These decisions are based upon costs

20   considerations as well as other business concerns such as the reliability and expediency of the transport. These and other factors in making transportation decisions are described in greater detail below.

Figure 1 schematically depicts the overall problem

25   encountered by companies as they attempt to solve their transportation planning needs. As seen in the figure, three counterbalancing forces come into play when a transportation planning manager 100 is attempting to make these decisions. The first force is represented by order information 101 that

30   details the desires of clients 104 or the company's sales divisions 105 to ship goods. Typically, this information includes source and destination, timeframe for the shipment,

2

the type of transport desired or needed, and the size and weight of the good. The second force is represented by the type of shipping or carrier services 102 that are made available by transportation carriers 106 such as common

5 carriers and/or private fleets. The type of transportation services made available by carriers 106 varies according to the type of transport (e.g. refrigerated truckloads, open rail cars, etc.), the geographical areas (shipping lanes) serviced by the carrier, and the prices charged for each type within

10 each lane. The last force is represented by constraints imposed by real life business factors 103, determined from a business's know-how regarding its own operations and limitations 107, that may rule out certain transportation solutions as not being possible or as not making business

15 sense. These constraints can include time windows, capacity limitations of shipping distribution centers, preferred carriers and relative compatabilities of products from different orders for joint shipment. In order to achieve an optimal planning solution, a transportation planning manager

20 100 must balance these three forces to determine an optimal transportation plan 114 that specifies transportation routes (lanes) 109, carrier selections 110, equipment selections 112, stop-offs 108 at crossdocks or distribution centers, time schedules 111, and expected costs 113.

25   In the making of transportation decisions, current technology allows transportation planning managers to automatically determine transportation costs, thereby allowing transportation planning managers to make more informed transportation decisions. For example, United States Patent

30 No. 6,233,568 (the "'568 patent") issued to Kara on May 15, 2001 provides a system and method for automatically providing shipping/transportation fees. In particular, the '568 patent

3

discloses a system and method for dispensing postage or other authorization information electronically by using a portable processor containing a maximum amount of pre-authorized postage which can be applied to any piece of mail or other

5   item. A plurality of carriers may utilize the portable processor to store and dispense credit value for authorization of various shipping services. Accordingly, transportation planning managers are presented with information regarding various shipping service providers fees and/or services

10   associated with particular shipping/delivery types desired by the transportation planning managers. This helps them make informed choices as to a most preferable method of shipment.

Current technology also allows transportation planning managers to track the status of goods in transport in real

15   time. Parcel and express carriers, such as Federal Express™, the United Parcel Service™ (UPS™) or DHL™, typically assign a unique parcel identification, known as an Air Bill number, to each delivery. This unique designation for each parcel is done by providing two-part forms to the transportation planning

20   managers, each including a unique, pre-printed bar code corresponding to the Air Bill number. One part of a form is attached to the parcel, while the transportation planning managers retain the other part of the form. The parcel identification barcode on the parcel is then scanned at each

25   stage of delivery to track the progress for the parcel. The barcode scanner communicates with a host computer to transmit the parcel ID to a host computer. The parcel ID and its location information are then transmitted by the host computer to one or more web servers, each including a database for

30   storing a record of the parcel ID's scanned at each location. The transportation planning managers, by running a web browser, may link through the Internet to one of the service

4

provider web servers, and thus the parcel status database
table, by specifying a URL (a "universal resource locator"
which is commonly known as a web page's address). The URL
usually points to an HTML file that is transmitted to the
5   transportation planning managers who are then prompted to
enter the unique parcel ID. The parcel ID is transmitted to
the service provider web server and used as search criteria by
the service provider, which returns the current location of
the parcel for display on the transportation planning
10   managers' web browser. When using paper Air Bills, however,
the transportation planning managers must manually record and
retain the tracking numbers for later use in looking up the
status of a particular package. Additionally, prior art
systems suffer from the fact that the transportation planning
15   manager must repeatedly re-access the URL to receive updates
as to the status of a freight movement.

        To further assist the transportation planning managers in
managing the transportation of goods, it is further known for
one or more carriers to automatically charge for shipping
20   services. For example, United States Patent No. 6,175,825
(the "'825 patent") issued to Fruechtel on January 16, 2001,
provides a method for debiting shipping services on the basis
of the respective transport service fee schedules of carriers,
centrally accounting operations of the services of various
25   carriers, and debiting of the transportation services
individually or summed together. In the '825 patent, a user
program is loaded into a modified postage meter machine that
has a printer and a telecommunication unit, and at least one
service fee table of a carrier being selectable therefrom.
30   The weight or some other physical quantity of a shipment is
entered the modified postage meter machine, and a service
value is calculated therein in conjunction with the selected

5

shipping parameters. The printer device of the modified postage meter machine prints out an identity ticket that contains the shipping parameters, at least including the shipping fee for the shipment. The information characterizing the shipment is stored in the modified postage meter machine and the implemented value identification of the shipment is transmitted via a telecommunication connection to a remote data center, either individually or summed. The data received in the data center are acquired, compiled and separately accounted for each carrier with an accounting program and an invoice is prepared at the data center and is communicated to the transportation planning managers for payment.

Despite these and other tools currently available to assist in managing the transportation of goods, the transportation planning managers may potentially make errors that result in non-optimal transportation decisions because of the complex nature of modern transportation planning and management. To assist the transportation planning managers, many organizations are increasingly relying on automated product transport management systems. However, the known automated product transport management systems generally suffer from numerous limitations including an inability to accurately and efficiently plan and manage complex freight movements.

A more ideal product transport management system would provide, inter alia, increased revenue, lower operating costs, and increased customer satisfaction. To achieve these and other goals, the more ideal product transport management system and method should substantially automate the execution of the shipping process on both domestic and international transportation. Specifically, the more ideal product transport management system should simultaneously consider and

optimize the organization's entire shipping requirements organization-wide. Additionally, such a product transport management system should have the flexibility to simultaneously optimize inbound, outbound, and inter-facility

5   freight movements to decrease transportation costs and increase customer satisfaction. Specifically, a product transport management system should allow an organization to collaborate directly with its vendors to optimize transportation throughout a supply chain. This functionality

10   would also allow an organization to dynamically select crossdock and pool point locations (i.e., transportation hubs or through-points) based upon the organization's business requirements and costs. Furthermore, an ideal product transport management system should consider pooling orders

15   into many multi-order sub-shipments from origin to destination, and should optimize each individual sub-shipment to take advantage of economies of scale and thus optimize the shipment of multiple orders simultaneously. Such an ideal product transport management system should be able to

20   automatically recalibrate the in-process shipment and consider each through-point to make automatically the best service and cost decisions.

An ideal product transport management system may further allow organizations to interact more directly with the

25   carriers through the Internet, an Intranet, or through another form of electronic communication (such as standards-based electronic data interchange, or "EDI"). In this way, organizations may automate transportation operations and may collaborate with carriers electronically and in real-time to

30   improve customer service and to better optimize total transportation needs. For example, improved integration with common carriers facilitates continuous move opportunities in

7

which the carrier completes a delivery at a first site, and is informed en route to the first site to proceed to a second site to pick up freight from the second site and deliver it to a third site.

5   Additionally, an ideal product transport management system having electronic communications with carriers could allow organizations to locate shipments in real-time and to update and trigger downstream electronic billing systems accordingly. This functionality additionally can permit the

10   product transport management system to monitor the status of a shipment and to alert the organization of any irregularities, such as unexpected delays or lost shipments. In this way, the organization may take remedial actions as soon as possible. By automatically monitoring the performance of carriers, the

15   product transport management system may also dynamically adjust future transportation decisions based on historical transportation data, such as unexpected costs or delays associated with certain routes or carriers. The product transport management system may then make improved

20   transportation decisions in the future. Direct interaction with the carriers may further allow the product transport management system to receive transportation bills, pay these bills, and charge an appropriate client an appropriately allotted amount for the freight movement costs. The

25   automation of the transportation payments and billing increases payment accuracy and reduces overall transportation costs.

SUMMARY OF THE INVENTION

       In response to the above-described and other needs, the

30   present invention provides electronic shipping and transportation planning, execution and freight payment

·8

managers and related methods that are useful to decrease shipment cycle time and cost while increasing services available to an organization and its clients. A first embodiment of the present invention allows organizations to

5 fully optimize transportation operations by facilitating the modeling and management of extremely detailed order requirements and business rules to identify the lowest-cost transportation solutions according to those order requirements and business rules. Additionally, a second embodiment of the

10 present invention allows organizations to fully optimize transportation operations by facilitating the implementation and management of selected transportation solutions. Further, a third embodiment of the present invention allows organizations to fully optimize transportation operations by

15 facilitating the management of freight movement costs by identifying carrier costs and charging an appropriate client an appropriately allotted amount for the carrier costs. Finally, a preferred embodiment of the present invention allows organizations to fully optimize transportation

20 operations by integrating the management of planning if optimized freight movements, execution of planned freight movements, and payment and collection of costs for completed freight movements.

According to the first embodiment, the electronic

25 shipping and transportation planning manager and related method of the present invention automatically process a large set of information pertaining to three primary areas: order information (source and destination, time frame, type of transport desired, etc.) detailing clients' desires to ship

30 goods, carrier information (type of transport, prices, etc.) detailing what transportation services carriers are willing and capable to provide, and constraint information (time

windows, capacity, business goals, etc.) which describe what solutions are not possible. This data processing produces one or more shipping solutions for each order wherein these solutions propose alternative freight movements, that include

5   particular carriers and equipment, to perform the clients' shipping tasks. The costs for each of these proposed freight movements are calculated (or "rated") to identify and select the lowest-cost solution for each order.

        According to the second embodiment, the electronic

10   shipping and transportation execution manager and related method of the present invention automatically tenders shipment requests to carriers and automates the monitoring of acceptances, also preferably transmitted electronically, from those carriers. Additionally in preferred embodiments of the

15   present invention, the electronic execution manager receives electronic updates regarding the status and location of shipments and stores these in a central execution database. This status and location information can then be transmitted to customers, distribution centers and the like regarding

20   planned, executed or en route freight movements. Additionally, in such preferred embodiments the information stored in this database can be used for external carrier performance tracking, private fleet performance tracking, and equipment tracking to improve the planning of future

25   transportation solutions.

        According to the third embodiment, the electronic shipping and transportation freight manager and related method of the present invention automatically authorizes payment and collection of costs for completed freight movements.

30   Preferred embodiments of the present invention are computer networks and related methods that facilitate the planning and management of the transportation of goods within

10

a supply chain. Further preferred embodiments of the present invention substantially automate and integrate three key business activities as discussed above; the planning of freight movements between a initial pick-up location and a

5   final drop-off location, the management and execution of those planned movements with both private carrier fleets and public carriers, and the accrual, accounting and subsequent payment of all shipping costs incurred.

        In such preferred embodiments of the electronic
10   transportation managers of the present invention, three separate yet integrated electronic managers, in the form of networked modules, perform one of each of the above-mentioned business activities. A route planning manager, in the form of a problem-solver module, uses a sophisticated load building
15   algorithm as herein described to identify and compare possible alternative freight movements from various potential route and stop sequences, modes of transport, and carriers. The decision making rules and information the problem-solver uses to make optional decisions regarding pending transportation
20   orders derives from business parameters that a transportation planning manager establishes for the system and from carrier availability and rate table information provided by external or fleet carriers. The information provided by the transportation manager may include, for example, policies or
25   operational requirements that his/or particular company follows. Using all of this information, the problem-solver performs various planning decisions before reaching an optimal transportation plan. The problem-solver may consolidate various orders and shipments into transportation loads. Then,
30   a determination is made for each load as to the best shipping mode (carrier, equipment type, route, etc.) and routes that meet delivery time requirements and other business constraints

11

are built. Lowest-cost alternatives are then identified to make the planned freight movements. Throughout the above functions, the problem-solver generates the most efficient load consolidations and makes the least-costly carrier and

5   private fleet assignments within the constraints imposed by the orders and the transportation planning manager.

Further, after the problem-solver planning solution is generated, the transportation manager can manually review and modify specific freight movements as necessary or desired, or

10   alternatively can route the output of the problem-solver consisting of the specific freight movements into an electronic transportation solution execution.

The electronic execution manager automates the tendering of shipment requests to carriers and automates the monitoring

15   of acceptances, also preferably transmitted electronically, from those carriers. Additionally in preferred embodiments of the present invention, the electronic execution manager receives electronic updates regarding the status and location of shipments and stores these in a central execution database.

20   This status and location information can then be transmitted to customers, distribution centers and the like regarding planned, executed or en route freight movements. Additionally, in preferred embodiments the information stored in this database can be used for external carrier performance

25   tracking, private fleet performance tracking, and equipment tracking to improve the planning of future transportation solutions.

The freight payment manager automatically accounts for the incurred carrier costs, allocates the costs to the proper

30   orders, and authorizes payment or invoices for all executed freight movements.

Preferably, in any one of the embodiments of the present invention a front-end user interface permits a transportation planning manager to interact with one or more databases to define a plurality of decision making algorithms to customize

5   electronic managers and leverage the expertise of the transportation planning manger regarding the organization. Additionally, the front-end user interface permits a transportation planning manager to review and modify files for each shipping order.

10   As will be readily appreciated by one of ordinary skill in the art, the transportation planning capabilities of the present invention can extend across an entire enterprise or alternatively can be used regionally for specific geographic areas of an enterprise. For example, transportation planning

15   can be done centrally for all locations of a client's distribution chain or alternatively, locally at each plant or distribution center. Of course, use of the present invention can also be adapted to have a blended approach wherein planning is initially performed at a central location, but

20   wherein local planners (instead of a central transportation manager), then have final review and approval over the transportation plan.

Additional features and advantages of the invention are set forth in the description that follows, and in part are

25   apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention are realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

30   It is to be understood that both the foregoing general description and the following detailed description are

13

exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings with like reference numbers representing corresponding parts throughout:

figure 1 is a schematic diagram depicting the various forces that must be considered by a transportation planning manager when selecting and scheduling freight movements to satisfy pending shipping orders;

figure 2 is a flow diagram depicting the overall process steps performed according to one preferred embodiment of the present invention;

figure 3 is a block diagram depicting the operational aspects and interactions of an electronic problem-solver module for selecting optimal freight movements according to preferred embodiments of the present invention;

figure 4 is a block diagram depicting the operational aspects and interactions of an electronic execution module for scheduling and monitoring planned freight movements according to preferred embodiments of the present invention;

figure 5 is a block diagram depicting the operational aspects and interactions of an electronic freight payment module and related method for forwarding payments and invoices for executed freight movements according to preferred embodiments of the present invention; and

14

figures 6, 7 and 8 are flow diagrams depicting the overall process steps performed according to one preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made in detail to the preferred

5   embodiment of the present invention, examples of which are illustrated in the accompanying drawings.

In the preferred embodiments of the electronic transportation managers of the present invention as shown in the figures, three separate yet integrated electronic

10   managers, each manager in this preferred embodiment being embodied in the form of networked manager modules as depicted in figures 3-5, perform the above-mentioned transportation activities in a manner as depicted by the flow diagram of figure 2. Specifically, referring to figure 2, after shipping

15   orders are received 201, a first manager module, the problem-solver ("PS") module 300 of figure 3, plans at step 202 optimal freight movements between a initial pick-up location and a final drop-off location. Next, at step 203, the optimal freight movements are planned in step 202 are executed and

20   tracked by a second manager module, the execution ("EX") module 400 of figure 4, so as to be executed using either private carrier fleets, public carriers or both. Finally, at step 204, a third manager module, the freight payment ("FP") module 500 of figure 5, accounts for incurred costs for the

25   executed freight movements, allocates the costs to orders received in step 201, and authorizes payment or invoices for all incurred freight movement costs that have been accounted for and allocated.

Figure 2 also demonstrates that, optionally, if the

30   planned optimum freight movements cannot be executed for any

15

reasons (examples of such reasons provided below), such unexecuted orders can be directed back 203a into the first module such that they can be combined with newly received orders and be incorporated into a new optimal freight movement

5   plan at step 202. Step 203a and the corresponding connecting arrows in figure 2 are shown in dashed lines to represent the optional nature of this flow.

As shown by the combination of figures 3,4, and 5, the PS module 300, the EX module 400, and the FP module 500

10   preferably are electronically connected and operate integrally to handle a transportation order all the way from planning the route and carrier for a particular shipment to managing the shipment's delivery and invoicing the shipment costs for the order to the customer after shipment has been completed. In

15   order to perform these functions optimally, all three modules require various interfaces and information flows as disclosed in figures 3-5. The information flows and their associated interfaces will now be discussed in detail.

Figure 3 schematically depicts the information flows and

20   interfaces of the transportation problem-solver module 300 according to embodiments of the present invention. As shown in the figure, the PS module 300 receives information inputs from common carriers 322, customers 320, sales offices or affiliates 318, and warehouses 316, crossdocks 314, and

25   distribution centers 312 (warehouses, crossdocks, and distribution centers collectively hereafter referred to as "locations"). The carrier interface 305 accepts information electronically from common carriers, preferably via EDI or the Web, pertaining to the types of transportation services

30   offered by the carrier as well as the rates that they charge for these services. This information includes travel lanes, equipment types, and rates for those lanes and equipment types

16

and is stored in the PS database 302 for use to calculate potential delivery solutions and to calculate the expected transportation costs for each route in the solutions to identify optimized solutions.

5   As shown in figure 3, a primary input into the problem-solver module 300 are the orders received from customers 320 and/or sales offices 318, via the order interface 306. Like carrier interface 305, the order interface 306 preferably accepts order information electronically, such as through the

10   Web or EDI. Orders received through the order interface 306 have a single origin/destination pair. Additionally, each order includes all the information that the problem-solver needs to schedule it for pick-up and delivery. This information can be conceptualized as being divided into three

15   parts which include header information, shipping units information, and routing information. The header information contains administrative data that, for example, identifies when and from where the order was received. The shipping units information identifies the type of product to be

20   transported, the physical dimensions of the product (including length, width, and height), number of units and weight of each unit. The routing information provides detailed origin and destination locations as well as time windows for pickup and delivery.

25   A location interface 307, again preferably connected to the locations (312, 314 and 316) electronically, provides remote locations on a transportation network or supply chain with a direct mechanism to submit new and/or modified information pertaining to the ability of locations to handle

30   orders, including whether they can stock new items, as well asthe current quantities of items in stock. The problem-solver logic 301 takes all these information streams and

17

stores them in a central PS database 302 for later use whenever an optimization batch is run. Additionally, a manager interface 304 also allows a central transportation manager 309 or administrator to set process or business rules

5   that are additionally stored in the database 302. Whenever a optimization batch is run in the problem-solver module 300, the current information regarding the carrier's orders locations and management rules stored in PS database 302 is accessed and utilized to compile various potential

10   transportation delivery solutions with all orders having several alternative routes compiled therefor (if more than one route is physically possible). The problem-solver logic 301 then, using carrier rate tables stored in PS database 302, calculates an expected cost for each alternative route and

15   selects the lowest cost route for each order as the proposed optimized solution. These proposed optimized solutions, known as "routed orders" 311, are sent via the routed order interface ("ROI") 303 to down-stream systems (or alternatively directly to the transportation planning manager via manager

20   interface 304 if he desires to have manual inputs on the proposed solutions). The primary output of the problem-solving module 300 is the routing order interface 303. The downstream systems according to preferred embodiments of the present invention include the execution module 400 of figure 4

25   and the freight payment module 500 of figure 5 as herein disclosed.

    As described below, the problem-solver logic 301 employs an algorithm that can split orders, combine orders for shipping together, and then build, solve, and save an

30   optimized transportation plan to PS database 302 and provide that proposed solution via the routed order interface 303 without active interaction from a transportation planner.

18

Each batch run of the problem-solver module can be configured by the transportation planning manager 309 to run automatically. A batch can be triggered to run at a preset time or at the completion of a download of certain orders, or

5   can be configured to run according to a preset schedule for specific horizon timelines. As will be readily appreciated by one of ordinary skill in the art, most problem-solver logic 301 batch runs will be triggered by the arrival of one or more new orders through the order interface 306. The fact that the

10   problem-solver batch runs can be scheduled to occur at the happening of certain events, automatically at specified intervals, or only upon manual initiation by a transportation manager adds great flexibility to the present invention.

Although not shown in figure 3, the problem-solver module

15   300 could also be provided with a distance interface. As will be readily appreciated by one of ordinary skill in the art, the rates quoted by carriers often depend upon the distance for which the order has to be transported. To this end, therefore, the problem-solver logic 301 will need a manner for

20   determining the distance between an origination and destination point quoted for each order. Therefore, the PS module 300 could utilize a distance interface for electronic communication with a distance calculating program such as MileMaker or PC*Miler.

25   The routed order interface 303 preferably outputs a flat file that details the proposed optimized transportation plan, consisting of one or more freight movements, developed by the problem-solver logic 301. This optimized transportation plan includes a detailed schedule of routes (at least one route for

30   each order) including dispatch times, expected return times, and expected wait time occurrences at each leg of a delivery route. Additionally, the flat file includes chosen carriers

19

for each shipment, the expected travel distances and times between stops, and the expected costs to be charged by each carrier. As discussed above, in alternative embodiments, the flat file provided by the routed order interface 303 could

5   optionally be provided directly to a transportation manager for review (either in a hard copy format or through a GUI-based computerized interface through either the ROI 303 or the manager interface 304).

According to preferred embodiments of the present

10   invention as depicted in figures 3-5, however, the routed order interface 303 provides the optimized transportation plan file, comprising routed orders 311, directly to an execution module 400 via EX module's unexecuted order interface 403 as shown in figure 4. The routed order interface ("ROI") 303

15   outputs information on freight movements for use by other systems. Each freight movement provided via the routed order interface is associated with a status code. Appendix 1 at the end of this application includes a table of status codes that can be appended to the database records of each order and/or

20   freight movement in the PS database 302, the EX database 402 and the freight payment database 502 in the FP module 500.

The execution logic 401 stores the routed orders in an execution management database 402. As seen in figure 4, the execution module 400 is connected to carriers 322 via the

25   tender interface 407. The execution module 400 uses the tender interface 407 to transmit tender offers (formal requests for shipping services) to the carrier(s) listed in the routed order interface flat file as having been selected by the problem-solver module 300. Preferably, each carrier

30   utilized by the problem-solver module 300 is electronically connected to the execution module 400 through the tender interface 407 such that tender offers (and subsequent

20

acceptances or declines as described below) can be sent electronically in annotated fashion through EDI, email or the Web. Alternatively, of course, means such as facsimile or telephone can be employed.

5   Once received, carriers can review tender offers and electronically provide an acceptance or decline of the tender offer to the execution module 400 via response interface 412. The execution module 400 can then re-route any declined orders back to the problem-solver module 300 as unexecuted orders 411

10   through unexecuted freight movement interface 410 such that the PS module may make a selection of a different carrier or transportation solution (this input not being explicitly shown in figure 3).

        Additionally, the execution module 400 contains a

15   shipment status interface 406 for use by the carriers 322 (both external and internal), warehouses 316, crossdocks 314 and distributors 312. The information transferred into the execution module 400 via shipment status interface 406 conveys information about shipments that are scheduled for delivery or

20   en route including when the carrier expects the route to leave, when the route has left a distribution center, when the route has arrived at a particular crossdock or warehouse, as well as expected delays either at the carrier end or at the location end. The execution module 400 is able to use this

25   shipment status information to provide updates to customers 320 or sales offices 318 via the customer status interface 408 as shown, or to trigger the accounting and invoicing features of the freight payment module 500 by sending it executed order information 409 via freight payment interface 405 as shown.

30   It will be readily understood that truck-load ("TL") shipments, less than truck-load ("LTL") shipments, parcel shipments, express shipments and other shipment types (these

shipment types being discussed in detail below) will not necessarily require the same functions from the execution module 400. Parcel and express shipments, for example, often do not employ carrier tender accept/decline transactions and

5   thus would not utilize interfaces 407 and 412 in figure 4.

The tender interface 407 in EX module 400 outputs tender offers that contain most of the same information that is provided to the EX module 400 from the ROI 303 via the unexecuted order interface 403, but the tender offer files are

10 organized in a linear structure such that they can be handled more easily by electronic commerce translation programs (such as EDI). Tender offer messages are sent to each carrier via the EX tender interface 407 whenever new unscheduled orders that require carrier tendering are received from the ROI 303

15 (assuming that such orders can be fulfilled by carriers that accept electronic tender offers). In cases wherein a particular selected carrier does not participate in electronic tenders, the EX module 400 could be adapted to send facsimile tender offers to such carriers automatically or to notify the

20 transportation planning manager 309 whenever a new routed order is received for such a carrier. As described above, acceptances or declines of such tender offers can be received electronically via the response interface 412. In situations wherein carriers do not send responses (acceptances or

25 declines) to tender offers electronically, such responses can be made in traditional manners (telephone, mail, facsimile, etc.) to the transportation planning manager and then entered by him manually via the manager interface 404.

The EX shipment status interface 406 as depicted in

30 figure 4 delivers shipment status messages to the EX module 400 from carriers 322, distributors 312, warehouses 316, and crossdocks 314, etc., regarding a load or shipment while the

22

load or shipment is en route. These status messages can
include update information such as expected early or late
arrivals, on time shipments received, or shipment completed
and/or cancelled. When such messages are sent in real time
5   from a carrier, these messages can be used to control alarm
generation within the EX module 400. Such alarms, for
example, can be used to send shipment status notifications to
a transportation manager 309 via manager interface 404, or to
sales offices 318 or to customers 320 via the customer status
10   interface 408.

The execution management ("EX") module 400 performs
several managerial functions including automated carrier 322
notification of tender offers, receipt of carrier responses
regarding acceptance of those tender offers, customer and
15   location notification as to the status of loads in transit,
tracking regarding the performance of carriers, alarm
generation regarding delays of freight movements, and an
output of executed orders 409 via freight payment interface
405. Similar to the ROI 303, the freight payment interface
20   ("FPI") outputs a flat file that identifies executed (i.e.,
completed) freight movements. The FPI output further includes
information such as when the freight movements were completed,
in addition to most of the information that was supplied to
the EX module 300 via the ROI flat file. As with the ROI, in
25   alternative embodiments of this preferred embodiment, the flat
file outputted by the FPI 405 could optionally be provided
directly to a transportation manager for review (either in a
hard copy format or through a GUI-based computerized interface
adapted to communicated with the EX module 400 through either
30   the FPI 405 or the manager interface 404).

The freight payment module 500 as depicted in figure 5
receives this flat file of executed orders 409 from the EX

23

module 400 via the executed freight movement interface 504 whenever particular freight movements have been completed. The freight payment ("FP") logic 501 then processes invoices received, preferably electronically via carrier invoice interface 505, from the carriers 322 (if the carrier was a public carrier for hire) and allocates shipment costs to customers 320 or to sales offices 381 depending upon from where the a given order originated. The processed invoices are then compared against the costs predicted by the problem-solver module (these costs being stored the EX database 402 and passed to the FP module 500 for storage in the FP database 502 upon completion of the freight movement) and results of this comparison are stored for later analysis. Invoices can then be passed on to the customer 320 or sales office 318 (preferably electronically via customer invoices interface 508) for final bill collection.

Additionally, the FP module 500 includes an accounts payable interface 507 and accounts receivable interface 506. In this manner, the accounts payable and accounts receivable of the transportation manager's company is automatically updated by the freight payment module 500 when invoices are processed and costs allocated.

When connected to carriers electronically as shown in figure 5 (e.g., via EDI), the freight payment module 500 authorizes payment to carriers automatically for completed freight movements. The FP module generates payment vouchers based upon either expected shipment costs (as determined from carrier rate tables by the PS module), carrier invoices, or delivery notices. These vouchers are then sent to an accounts payable system (not shown) through the accounts payable interface 507 as shown in figure 5. The FP module, of course, can also be easily adapted to accept completed payment

24

information in return from accounts payable and accounts receivable systems (not shown) to update records in the FP database 502. Additionally, invoices for allocated freight movement costs can be sent via customer invoices interface 508

5   to customers 320 and sales offices 318 (to request payment for charges invoiced by the carriers) while accounts receivable records can be automatically sent to an accounting system via accounts receivable interface 506.

The problem-solver logic 301, execution logic 401 and

10   freight payment logic 501 will now be discussed in detail with respect to the flow diagrams of figures 6-8. Figure 6 is a flow diagram depicting the overall process steps performed according to a preferred embodiment of the present invention wherein the problem-solver module 300, the execution module

15   400 and the freight payment module 500 are arranged such that they form integrated network that can handle transportation management completely from the point of collecting rate table information from carriers and receiving orders from customers all the way up to issuing invoices to those clients when the

20   orders have been fulfilled. As will become apparent from the discussion to follow, the steps of figure 6 are performed by the three above-described modules in a cooperative manner such that the PS module performs the actions required by steps 601-603, the EX module performs the actions required by steps 604-

25   608, and the FP module performs the actions required by step 609.

As discussed generally above, the PS logic 301 takes various inputs into account in order to route and then provide cost ratings for various shipments at a given time. The

30   problem-solver logic 301 of this preferred embodiment is adapted to leverage a user's knowledge of his or her transportation network rather than sequentially consider every

possible route through a network as a solution for a particular order. Referring to figure 6, it is shown that the decision making rules and information the problem-solver logic uses to make optimal decisions regarding pending

5 transportation orders are first defined at step 601 before a batch process is run by the problem-solver logic (that is, before any orders are ever received at step 602). The rules and information used by the problem-solver logic are a combination of templates and business parameters that a

10 transportation planning manager establishes for the system and carrier service availability and rate table information (as discussed below) provided by external or fleet carriers. Transportation planning managers can, for example, by using the manager interface 404, define route planning rules, create

15 templates that define legs for multiple leg routes and multiple mode routes (the entering of such templates, while done at step 601 prior to a batch run, will be discussed in detail below with respect to step 603, figure 7, and specifically with respect to multi-leg routes) or enter

20 constraints to enforce policies or operational requirements that his particular company follows. All of this information is taken into account once the problem-solver begins to compile optimal transportation plans.

The PS logic according to embodiments of the present

25 invention routes every suitable freight movement that could fulfil a transportation order within the rules set by the transportation planning manager. A particularly advantageous feature of the present invention involves the use of priority routing rules in the PS database that enable a transportation

30 planning manager to influence the creation of loads and freight movements when lowest cost is not the most important consideration. Typically, after it identifies all potential

26

suitable freight movements for each order, the PS logic identifies the lowest cost transportation solution. This solution, however, is bound by a set of customer service requirements and the priority routing rules that limit the

5   field of possible transportation solutions. These routing rules can include: time windows indicating hours across the day for which pickup and delivery are available, carrier ratings indicating levels of expected performance by the carriers, order pickup and delivery sequences for multiple leg

10   routes, compatible equipment types to service a particular location, federal and/or state regulations governing the transportation of certain material types (for example, hazardous material), etc.

     Additionally, at step 601 the PS logic accepts rates for

15   each carrier type, and each carrier within the carrier type. These rates are specified in a plurality of tables which are stored in the PS database 402 for use during batch runs. Such rate tables are stored therein for each carrier type, including truckload ("TL"), less than truckload ("LTL"),

20   parcel and package carriers (both being herein referred to as "package carriers"), railroads, air, and sea transporters. Disclosure that is presented below with respect to the rating aspect of the PS module (sub-step 704 of figure 7) will discuss sample shipment cost rating tables for some of the

25   carrier types listed above.

     Batch applications such as are employed by the PS module are powerful in the sense that they can look at an entire complex problem, such as a large group of orders available to be shipped through a large number of possible carriers, and

30   create a one-time low-cost solution. At some point, however, the transportation planning manager must decide when the PS logic 301 will begin a batch process to generate freight

movement plans (step 603 of figure 6). Typically, the PS
module will be configured such that a batch process will begin
to run once a certain amount of orders are received 602.
Alternatively, of course, the transportation planning manager

5   could elect to manually initiate step 603.

When the PS logic begins its batch run at step 603 to
generate an optimal freight movement plan (for all orders
received since its last batch run) it performs several sub-
steps which are detailed in figure 7 as a separate flow

10   diagram. Figure 7 demonstrates that step 603 of figure 6 can
be more specifically described as four sequential sub-steps.
The sub-steps that comprise a batch run of the PS logic
according to preferred embodiments of the present invention
will now be discussed with respect to figure 7. Detailed

15   discussion of the remaining steps of figure 6 will be resumed
later below after complete discussion of figure 7.

During a batch run, the problem-solver logic 301 first
consolidates various orders and shipments into transportation
loads at sub-step 701. Then, a determination is made at sub-

20   step 702 for each load as to the best shipping mode (carrier,
equipment type, route, etc.) for transporting the load. In
order to achieve the above planning sub-steps, the system uses
various types of information including data detailing the
required freight movements, tables itemizing resource

25   availability and cost, operational requirements of the
industry, and general company rules and policies entered by
the company's transportation planning manager. After modes
have been selected, multiple alternative freight movements
that meet delivery time requirements and other business

30   constraints are built for each load at sub-step 703. The
lowest-cost alternative freight movement for shipping each
load is then identified at sub-step 704 and selected for

28

inclusion in the optimal transportation plan. Throughout the above functions, the problem-solver generates the most efficient load consolidations and makes the least-costly carrier and private fleet assignments within the constraints

5   imposed by the orders and the transportation planning manager.

In all sub-steps of figure 7, the problem-solver module of the present invention is adapted to leverage a user's knowledge of his or her transportation network rather than look at every possible route through a network.

10   Transportation planning managers can, by defining leg-based account profiles (at step 601 of figure 6 prior to a batch run), set planning rules and specify legs for multi-leg routes and multi-modal routes. For example, a transportation manager can utilize his knowledge of his company's distribution

15   network by specifying that a particular batch sequence be set up as a three-leg route wherein the middle leg is performed via rail with a specific rail carrier.

Whenever feasible, at sub-step 703 the PS logic will attempt for each load to construct routes according to

20   multiple leg routes on a particular lane, then construct two-leg routes through any through-point setup by the planning rules, and, finally, construct a direct shipment. In addition to designating multi-leg trips, through-points can be defined such that any order on an appropriate lane will first be

25   routed there-through, if possible. In the case of both though-points and multiple leg routes, application of these planning rules by the PS logic processes depicted at step 703 is performed only on a lane by lane basis (i.e., a through-point or multiple leg route only applies to one or more

30   applicable lanes).

More specifically, according to embodiments of the present invention as described above, the PS logic at sub-step

29

701 considers combining various separate orders in a given batch for delivery due to those orders having a common shipping and/or delivery location. Certain shipping locations within the PS database can be designated as belonging to a

5 shipping complex. This is typically the case when a large company has multiple distribution centers or plant locations but wishes to have its orders delivered to a single location to provide price consolidation and order consolidation. Thus, any order designated as going to a particular plant location

10 of such a company would be combined with any other orders designated as going to any other location belonging to that company. In this manner, orders that are good candidates for consolidation are more easily identified and economies of scale are advantageously employed.

15 Similarly, the PS module automatically splits large orders into one or more sub-orders when those large orders are too large to be shipped together (such as because the order is too large to fit in a single trailer on a single TL or LTL shipment). Any freight movements resulting from split orders

20 will be tagged as split orders when they are sent through the ROI to downstream systems such as the EX. The EX then, therefore, can combine the two freight movements into a single order record for purposes of tracking and tracing, as can the freight payment module for purposes of freight movement

25 charges allocation and invoicing.

Many carrier types are available in the transportation industry. At sub-step 702, the PS logic 301 determines the best shipping mode for a given order. This determination depends upon many factors including the kind of good, the

30 size/weight of the freight, and desired delivery timelines. Typically, large and/or heavy materials with relatively remote delivery deadlines can be sent either on commercial or private

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fleet truck loads ("TL") while medium size or medium weight freight movements can be accomplished using commercial or private truck carriers in a less than truck load ("LTL") scheduling. Large to medium weight or size freight movements

5 can also be accomplished over land via rail transportation or even air transportation. Large to medium size and weight freight movements, particularly for transcontinental shipments, can also be accomplished via sea barge.

Smaller size and weight packages are typically shipped

10 either via standard parcel service (such as the U.S. Postal Service, UPS, etc.) or via express or overnight service (for example Federal Express). Generally speaking, transportation rates of parcel, express and overnight service packages increases with speed of delivery (overnight vs. three-day) and

15 size and/or weight of the package. The timeline for delivery of an order is one of the major factors considered by the PS logic at sub-step 702 when considering whether to use package carriers.

Additionally, one or more carrier types are often

20 employed in combination to form an intermodal carrier route. A typical example would be for a large-weight shipment to be scheduled to run via TL carrier from the distribution center to a sea port and then transfer from the sea port oversea via transatlantic barge to Great Britain.

25 Disclosure below with respect to the rating aspect of the PS logic (sub-step 704 of figure 7) will disclose sample shipment cost rating tables for some of the above carrier types to help further illuminate the differences between the above carrier types and thus indicate when one carrier type

30 may be more beneficial for use than another carrier type for a particular category of order requests.

31

For each order being processed in a particular PS batch, the PS module at sub-step 703 performs a first cut that determines which carriers (in the mode or modes selected at sub-step 702) are possible to service the particular order.

5　Sub-step 703 essentially takes the resources identified in sub-step 702 and searches the services offered by carriers for matches within relevant lanes. For example, a large freight order that needed to be moved via truck load from New York to Los Angeles could not use a TL carrier that only operated in

10　the southeast United States. In performing this first cut, the PS module considers: time windows (such as by hour of the day across the week) that the carrier is available for pickup and delivery, order, pick-up and delivery time windows, order pick up and delivery sequence (such as where a carrier is

15　being utilized for a multi-leg route), whether the carrier has compatible equipment to service a particular order or location (such as where the carrier needs a refrigerated car to transport perishable food goods), overlap of geographic service areas and proposed transport route, and order grouping

20　for compatibility and/or incompatibility purposes.

Additionally, at sub-step 702 the PS logic considers combining LTL and package shipments into trailer size (i.e., TL) loads to increase the efficiency of the trailer loading process in the warehouse. The shipments are grouped by

25　carrier by breakbulk, which is a location associated with lanes. Typically, the trailer building PS logic is applied after the PS module has completed an initial assignment of of orders to the standard carrier approaches (TL, LTL, package, etc.). Outbound shipments that were created by the problem-

30　solver with these standard carrier approaches then are brought into this trailer building PS logic. In these instances, the shipments already have proposed carriers. The shipments that

are assigned to LTL and package carriers are grouped by carrier, origin, and breakbulk. If there is a compatible trailer type available, the shipments with the same carrier, origin, and breakbulk will be placed onto the trailer if they exceed the breakbulk's minimum quantities. Additionally, it should be understood that all shipments combined by the trailer building PS logic must have overlapping time windows. Additionally, the commodities for the shipments that are placed on combined trailers must be compatible with each other and compatible with the trailer type.

For freight movements comprising such built trailer loads, the early depart time for the trailer is set to the latest of the early depart times for the shipments on the trailer and the late depart time for the trailer is set to the earliest of the late depart times for the shipments on the trailer. The combined trailer built through this process is then submitted as a proposed solution to the rating algorithms of the PS module. If the combined shipment offers a cost savings over the individual shipments, the combined shipment is sent through the POI and the individual shipments are discarded and vice versa.

As described generally above, whenever the PS module builds a trip at sub-step 703 for a batch of specific orders, it attempts to route the orders at least once in each of the following ways: directly to their destinations, through a single through-point (such as a crossdock or distributor), and via multiple through-points (referred to herein as multiple leg routes or "MLR"). The PS then generates a cost rating for each trip and determines which routing method produces the best cost solution at sub-step 704.

Each order received in the PS module preferably includes a package type that indicates what method is used for storing

33

the commodity or product that is being shipped. These package
types can include palates, slip sheets, or floor loads (i.e.,
loose boxes). This package type information can be used down
the line by the problem-solver in sub-step 703 in determining
applicable loading methods. As will be readily appreciated by
one of ordinary skill in the art, a package type will
necessarily determine whether or not certain loading methods
can be used to load or unload a particular carrier at a stop.
For example, forklifts can be used to move palates and thus
decrease loading and unloading time while floor loads cannot
be moved easily by forklifts. Therefore, whenever the PS
module encounters floor load package types for a particular
order, it knows that it will take longer to load or unload
that particular order at a stop and thus make routing
schedules accordingly during sub-step 703.

A multi-leg route ("MLR") leg proposal is associated with
a shipping lane by the PS and represents a particular route
for all orders in that lane that the transportation planning
manager expects to be particularly efficient for his
organization's shipping needs. A multi-leg route freight
movement (or portion thereof) specifies a sequence of through
points (crossdocks) that a particular freight movement must
flow through. The transportation planing manager can
associate an account profile with each leg if necessary (such
as during step 601 of figure 6). Prior art systems and
methods for transportation planning often allow an order to
traverse through a single through-point only on its way from
source to destination. The present invention overcomes this
limitation via the use of an organization's internal knowledge
with respect to its supply chain.

In order to process MLRs efficiently, the PS logic only
utilizes such proposed MLR routes stored in the PS database as

34

opposed to considering every possible multiple through-point route for every load. These proposed MLR routes are entered by the transportation planning manager prior to the running of a particular PS module batch and are based upon the

5   transportation planning manager's knowledge of his or her particular supply chain. Therefore, whenever the PS module runs, the following choices of routes will be considered for every possible freight delivery: an MLR for each possible combination of proposed MLR legs within a particular order's

10   lane, a one-stop route through any of the PS defined regular through points set up on the order's lane, and a direct route from the origination point to the destination point.

Suppose there are three orders that originate from three separate source points in Malaysia with the orders destined

15   for two different destination points within the United States. The first and second orders from Malaysia are heading to Chandler, Arizona and the third order from Malaysia is headed to Hillsboro, Oregon. The MLR legs corresponding to each lane are set up by the transportation planning manager during

20   configuration. In this particular build, one MLR proposed route containing the three crossdocks PEN (the Malaysian airport), LAX (the port of entry into the United States at Los Angeles) and PDX (the airport in Portland, Oregon) is set up before the PS batch run on a lane from the third of Malaysian

25   origin point to Hillsboro, Oregon.

A second MLR proposed route is entered specifying a lane including the first and second Malaysian source points that are to be delivered to a single location in Chandler, Arizona. This second MLR proposed route contains PEN, LAX and PHX (the

30   airport in Phoenix) as the intermediate through points.

When the above orders are considered in the problem-solver module during a batch, an initial decision is made by

35

the PS on which route is best for each order. All eligible
MLRs proposed by the transportation planning manager are
compiled by the PS logic during this sub-step of a batch run
along with any potential through point trips (comprising a

5   single stop) and direct routes for each order from origination
to destination point. Estimated costs for each route are used
to make the decision after all potential freight movement
paths have been identified. While some savings are realized
through the consolidation of one or more orders together, it

10   should be understood that the cost calculations for an MLR by
the PS module (as well as TL, LTL, air, rail, and sea freight
movements) are essentially estimates since the full impact of
multi-stop trips and result in accessorial charges is
unpredictable. Having made an initial determination about the

15   best route, the PS module puts together all legs of a
subsequent MLR. This sequential leg building procedure allows
for all bundling opportunities to be accounted for. For
example, in the above scenario all three orders will be built
onto the same trip on the leg spanning PEN and LAX.

20   Additionally, the two trips originating from the first and
second locations in Malaysia that both are traveling to the
location in Arizona can both be routed together from LAX to
PHX and from PHX to their final destination via truckload.
Bundling freight movements together in this manner typically

25   results in reduced costs due to advantages from economics of
scale.

        As indicated above, the PS module's manager interface is
adapted to allow a transportation planning manager to define,
prior to PS batch runs, potential MLR legs. According to

30   preferred embodiments, this is accomplished using MLR
templates. A MLR template basically comprises an input
mechanism (such as in the form of computer form or checklist)

36

that enables a transportation planing manager to suggest a sequence of through-points (like "crossdocks" which can be defined generally as an intermediate freight consolidation point) that are associated with a given transportation lane

5   (thus leveraging the knowledge and experience of the organization). The MLR templates are stored in the PS database and, when taken together by the PS logic during a batch run, serve as a series of building blocks around which the PS logic will attempt to construct MLRs for any freight

10   movement in that lane. In other words, when a MLR template is entered into the PS database, it is considered by the PS module as a possible route through which to ship orders that can pass through that lane. Therefore, instead of considering all possible combinations of MLRs, the PS logic simply tries

15   to fit the orders for the current batch first into the legs as proposed by the MLR templates, and then it attempts to consolidate the remainder of the legs of the shipment at a later time (either automatically or manually with the assistance of a transportation planning manager).

20   Capacity limits for a proposed MLR can also be defined within a MLR template by the transportation planning manager. When capacity limits are assigned to an MLR template, they override other limits that may have been defined for crossdock locations used in the template. (However, when orders that are

25   not part of an MLR trip are routed through the same crossdock location, the crossdock's own capacity limits, if any, apply.)

MLR capacity limits can serve as a powerful mechanism for influencing how the PS logic decides to route orders via a specific MLR trip. In preferred embodiments of the present

30   invention, three different capacity thresholds can be set (thus defining four ranges) within each MLR template; a lower capacity MLR threshold below which all orders are routed

37

through the MLR's through-points, an upper capacity MLR
threshold above which no orders are ship via the MLR's
through-points, and an intermediate capacity MLR threshold
that divides the area between the upper and lower capacity MLR

5   thresholds into upper-middle and lower-middle regions. Each
of these four regions designates a different treatment by the
PS logic during any running of a particular batch process that
considers MLRs on the particular lane.

       If orders that fall into a lane, serviced by a given MLR
10   template, have capacities that fall below the lower capacity
MLR threshold, these orders will be claimed, so to speak, by
this MLR during the PS logic's trip building process.
However, the same orders may fall below this limit for other
defined MLRs as well (and for other types of through-points,
15   like crossdocks) and may therefore be claimed by multiple MLRs
and through-points. To route these orders, the PS logic
ultimately routes all of them and then makes a cost-based
decision between the MLRs and other through-points that claim
the bundle of orders at sub-step 704 as discussed below.

20   This behavior in the lowest region is rule-based, which
means that when orders fall below this capacity limit, and are
claimed by an MLR (or single through-point), the problem-
solver logic 301 rules out the direct routing option for these
orders even if it may lead to a lower cost trip. Thus, a
25   direct route would not be compiled and sent to sub-step 704
for a cost calculation and comparison.

       The intermediate capacity limit separates the area
between the upper and lower capacity limits into two middle
capacity ranges, the upper-middle and lower-middle ranges.
30   The problem-solver logic treats orders differently depending
on whether their capacities fall above or below this limit.
If order capacity falls within the lower-middle range, the

38

problem-solver will make a completely cost-based decision about how to route these orders. Thus, orders falling within an MLR's lane (and having a capacity in the lower-middle range) will be routed on a trip created from a given MLR

5   template only if it represents the best cost trip for the orders. To encourage cost-based decision making, capacity limits can be set by the transportation planning manager such that this range is the widest. This purely cost-based behavior will be the default if no capacity limits are set for

10   a given MLR template.

        If order capacity falls within the upper-middle range, the problem-solver logic will make an initial decision not to route the orders on a trip created from a given MLR template. This initial behavior is rule-based, meaning that, even when

15   this MLR represents the best cost trip for certain orders, they will not be routed through it if their capacity falls above this limit. However, later in the problem-solver's trip building process, routing options for orders that fall into this capacity range are re-evaluated. The PS logic, if so

20   configured by the transportation planning manager, could then consider whether alternate routing options could yield lower cost trips for such orders. It is significant to note that at this point, other trips and MLRs, which did yet exist the first time around, can now be considered. Final routing

25   decisions are ultimately cost-based. The overall effect of the intermediate capacity limit is that as its value is moved closer to the lower limit, the likelihood decreases that orders will be routed through this MLR.

        If orders that fall into a lane, serviced by a given MLR

30   template, have capacities that are above the upper capacity limit, the MLR template (and the through-points it defines) will not be considered an option for these orders. Like with

orders falling below the lower capacity limit, behavior in the area above the upper capacity limit is strictly rule-based. It effectively requires that even when a trip created from this MLR template might yield the best cost trip for certain

5   orders, if their capacity is more than the limit set here, they will not be routed through MLR. The PS logic will, however, still consider other MLR templates, other through-points, and the direct routing option.

      In some cases, setting capacity limits can reduce the

10   amount of time the PS takes to schedule a group of orders. For example, if it makes good business sense to avoid sending orders weighing more than 50,000 pounds through an MLR, set the upper capacity limit for an MLR should be set to 50,000 pounds. When the problem-solver considers an order that

15   large, it will not spend any time attempting to schedule the order on the MLR.

      Even more powerful is the potential that capacity limits provide for helping the PS logic choose MLR templates with specific attributes. Let's say, for example, on a given lane,

20   you set up one template that uses air transportation for its longest leg, and other templates that use ground transportation only. As will be readily appreciated by one skilled in the art, a transportation planning manager can use capacity limits to ensure that only relatively small orders

25   are routed via the MLR with the air transportation leg.

      For example, if a transportation planning manager wished to use the capacity limits for an MLR template so that it will be used to create trips only for orders with a capacity of less than 150 pounds he could simply set the lower limit at 50

30   pounds, the intermediate limit at 100 pound, and the upper limit at 150 pounds. This aspect of MLR capacity limits

40

allows the PS logic to choose between different MLRs on the same lane, and between an MLR and other routing options.

Assuming the PS module 300 is provided with a plurality of through-points or crossdocks, a MLR could be built
5   dynamically by the PS module during each batch by considering every available combination of crossdocks to get the shipment from its origin to its destination. As the order batches become more complex (involve more shipments going to more locations), forcing the PS module to try out every possible
10   combination would increase its run time to unacceptable levels even using extremely sophisticated and expensive hardware. The present invention alleviates the above-referenced computational problem by utilizing MLR leg proposals provided by the user. These proposed legs leverage the company's own
15   business knowledge to influence how the PS logic builds multi- leg trips. Therefore, instead of starting the procedure of formulating MLR shipments from scratch each time a new batch of orders is routed to the problem-solver, the problem-solver uses the proposed legs of the route to help compile feasible
20   and cost-effective MLR trips.

Additionally, at sub-step 703 the continuous moves PS logic enables the PS module to create what are known in the transportation industry as "continuous move tours." A continuous move tour defines a set of truckload trips (or
25   loads) that are joined together to form one continuous route (or continuous move) using the same truck. It should be understood that two or more trips can be linked by empty legs wherein the truck has no cargo, however, to be profitable the number and length of the empty legs need to be minimized. TL
30   and LTL carriers often provide discounts whenever shipments are consolidated into a continuous move tour due to the high vehicle and driver utilization they achieve.

41

The PS logic can add a new trip to the end of an existing trip or tour (the PS logic recognizing when one freight movement ends and where another begins) or can combine two freight movement trips via truckload created during an earlier

5   PS module run to form a new continuous move tour. Preferably, two trips created by the PS module are combined together to form a continuous move tour if the continuous move would cost less than sending both trips separately and via different carriers and if the tour can be completed feasibly.

10   Another long-standing issue with respect to transportation management is that transportation managers or prior art systems and methods are unable to take into account location limitations that exist outside of the transportation managers enterprise or the carrier fees. A typical example of

15   such a location limitation would be where a distribution center has only a limited number of truck doors or other related throughput constraints stemming from limited work schedules on weekends. As such, prior art systems and methods for transportation management would have a bias toward

20   shipping freight movements at their earliest, best start time. That is, when multiple TL trip start-times will result in the same cost for a trip, the earliest of these times was typically chosen as the start time for each freight movement. This rule often resulted in many freight movements being

25   scheduled for a service time simultaneously at a single location (such as the distribution center). Since these locations typically have restrictions on the number of freight vehicles they can handle simultaneously, as well as how much loading or unloading work they can accomplish within a given

30   amount of time (such as due to workload constraints), it is often desired that service time for trips at a location be staggered. Furthermore, in the case of a depot location or

42

crossdock that is a stop station for private fleet carriers,
it is often desirable to stagger trip start-times to closely
follow truck driver start-times and shifts. Therefore, the
present invention incorporates location constraints that

5   enable the staggering of location service times to solve such
problems.

According to the present invention, a set of time windows
are defined with respect to each crossdock and/or warehouse
and stored in the PS database. Each of these location

10   constraints ("LC") time windows will have associated
activities constraints. The activity constraints can be
represented in a variety of ways including a number of trucks
that can be serviced in a given amount of time, a number of
order quantity measurements (i.e. weight, cube, pieces,

15   pallets, etc.) that can be handled in a given amount of time,
and/or a maximum weight size per truck order that can be
handled. Additionally, the present invention allows such LC
windows to be designated as either hard or soft to indicate
that the activity constraints are to be strictly enforced or

20   are to result in a cost penalty within the problem-solver
logic, respectively. If the constraints are soft, the cost
penalty will be specified in a cost per excessive use or unit
and incorporated into the selection of the route and/or
solution by the PS logic during batch run sub-step 704.

25   According to embodiments of the present invention, the
transportation planning manager can define location
constraints using LC templates (similar in efect and operation
to MLR templates as described above) that take into account
limitations that exist with respect to crossdocks, through

30   points, distribution centers and the like. These limitations
can include the physical limitations of the center (how many
forklifts are available) or the work schedules of the workers

43

at that particular location. These LCs are then stored in the PS database and used by the PS module during batch runs at sub-step 703 of the PS logic.

As mentioned above, within an LC window, constraints can be designated as hard or soft to indicate whether the activity constraints are to be strictly enforced by the PS module or are to result in a cost penalty when the PS logic begins calculation of relative location-constrained rates of possible routes. If the constraints are designated as soft, the cost penalty will be specified in a cost per excessive unit. In particular, location constraints are used by the PS logic with respect to TL and LTL carriers. A discussion of decision algorithm employed by the PS logic when two or more proposed routes are completing for location-constrained resources is provided in Appendix B below.

In sub-step 703, the PS logic also considers what is known in the industry as multi-shifting. Any resource utilized by the PS logic is identified in the PS database by carrier, lane and equipment type. For example, a particular resource (truck) belongs to the XYZ Trucking Corporation, is a 48 foot flatbed truck, and is designated to operate within the Pennsylvania to Maryland lane. In many prior art transportation management systems, once a particular resource is assigned to a trip that resource is exhausted for the rest of the planning horizon (such as the rest of the day) and cannot be reused for another trip on later runs of the transportation management system. As a result, if a particular resource receives a short trip that does not exhaust its usefulness for a whole day, that resource will remain unoccupied for the remaining portion of the planning horizon.

44

To eliminate this under-utilization, the PS logic assigns a time window to each calculated trip that represents the entire time that that resource will be unavailable for further use. In this manner, the same 48 foot truck can service

5   delivery that lasts from 6:30 a.m. until 11:30 a.m. and a second delivery that lasts from 1:00 p.m. to 8:00 p.m. To ensure that the time windows are properly set, the transportation planning manager and the carriers are able to specify a fixed down time between trips within given lanes and

10   the PS calculates estimated route times for TL and LTL freight movements.

Batch applications such as are employed by the PS module are powerful in the sense that they can look at an entire complex problem, such as a large group of orders available to

15   be shipped through a large number of possible carriers, and create a one-time low-cost solution. Batch applications, however, are inherently limited in their ability to provide continuous optimization over time. At some point, the users of the batch application need to start off the process, which

20   will optimize all information that it has at that particular point and time. Unfortunately, the enterprise using the optimization engine is often still allowing changes to the problem components (a.k.a. orders or carrier availability) that were just optimized. In the field of transportation

25   management, these changes include order deletions, modifications and additions that, if known at the time of optimization, would have resulted in a much different solution. While an enterprise can limit the ill effects from changes and deletions by enforcing strict business process

30   rules around order changes and cut-off times, such strict business process rules often conflict with the drive for total customer satisfaction. Thus, it is desirable to have the

ability to update and/or correct order information after a
batch process, i.e., a PS module optimization bath as
described above, has been run.

Commonly, situations will occur where some of the orders
5   in a current PS batch (whose status are "N", designating new
un-routed orders) are going to a same destination from a same
through point or origination point as some of the already
existing freight movements that have been tendered by the EX
(having a status "T"). (The database status codes employed in
10   preferred embodiments of the present invention are itemized in
Appendix A.) Whenever the PS module runs a batch, since
tendered loads are not necessarily considered part of a batch
because they are not "new" orders, rules may be set by the
transportation planning manager where the PS module considers
15   making any such overlapping new orders an "add on" to any
compatible tendered existing trip. In this manner, a new
freight tender would have to be sent via the EX module to the
appropriate carrier.

Additionally, preferred embodiments of the present
20   invention allows the PS logic at sub-step 703 to add to an
already optimized route (in other words, it adds an order that
would "tag along" with an already optimized route if that
order was originating from and going to similar locations
where the route provided through the routed order interface).
25   As shown in figure 4, the EX module could re-route unexecuted
freight movement orders 411 that had either been routed,
tendered, accepted by carriers after tendering so long as
those routes have not yet been dispatched. In this case, the
problem-solver would use this existing freight movement and
30   add the new order onto it and re-send that freight movement
back through the routed order interface to the EX module. The
EX module then re-tenders the order (identified in the EX

46

database as a new order which is related to the old order having the routed tender or accepted status in the database) and the carrier would then determine whether it could handle the updated order. In the event that the updated order could

5   be handled the execution updates the new orders record in the EX database. In the event that the updated freight movement could not be handled by the carrier, the EX module sends the updated order back to the problem-solver and removes the original order from the PS database such that changes to that

10   trip are now not allowed. Alternatively, the PS can then try to re-tender the updated order to a new carrier and, if accepted, cancel the original order.

Referring to figure 7, at sub-step 704 the rates for each proposed route from sub-step 703 is calculated using the rate

15   tables stored in the PS database 302. TL rate tables specify shipping rates for each carrier by equipment class. The rate is then specified in each table in terms of dollars per mile, a minimum rate, and/or a flat rate.

LTL rates are specified by carriers for each class in

20   terms of a minimum rate and weight breaks. Package rates are specified for a carrier's weight breaks and charges for transportation within a particular zone. (The zones being defined by a particular carrier). Rail rates, air rates and package rates can be defined as a combination of any of the

25   above. Intermodal freight movements are rated using a particular carrier type rating tables for each leg of the trip.

With respect to TL and LTL rating, the PS module must be able to determine a calculated distance that the shipment will

30   travel from the origin to its destination. As will be readily appreciated by one of ordinary skill in the art, the PS module can be readily adapted to use calculated distances obtained

47

from latitudes and longitudes, zip codes, or street addresses
as inputs into a readily available commercial distance
calculation software such as PC*Miler and MileMaker.

The rate tables for each carrier type also typically
5   depends on one of two variables (or sometimes both), distance
from origin to destination and weight of the freight. With
respect to distance traveled, the PS system supports five
types of rating methods for TL trips. They are flat rate,
metric rate, fixed plus variable rate, mileage rate, and
10   radial rate. A radial rate is a freight rating and routing
method by which freight movement cost is determined using the
sum of straight-line distances between each end point on a
freight movement's various legs as the distance variable.

With respect to the weight variable used in each of the
15   rate tables, the PS module supports the use of standard
weights (i.e., pounds or kilograms) or dimensional weights.
In the transportation industry, a dimensional weight is a
calculation of the shipment's weight based upon its volume
metric standard in addition to its actual weight.
20   Essentially, it acts as a equalizer to ensure that large and
bulky, yet lightweight, objects that consume a large portion
of a carrier's capacity costs comparatively as much as a more
dense yet smaller object. A dimensional weight is calculated
by multiplying the length times the width times the height of
25   each package and/or object and dividing that volume by an
appropriate dimensional weight divisor. The dimensional
weight divisor is specified specifically by each carrier for
each of its offered carrier type services. Additionally, the
dimensional weight divisor can vary according to the lanes for
30   the transport (e.g., domestic US. export shipments). For
example, a typical domestic shipment dimensional weight
divisor in the United States (for package dimensions listed in

48

inches) is 194, but for US export shipments the divisor is 166.

Carriers typically require that their rate be determined using the larger of the two weights, that is the dimensional weight or the actual weight of the shipment, to determine the price that they charge. Dimensional weight rating is particularly applicable to industries, such as the high tech industry, wherein many boxes are shipped that each have a fairly low weight. For a multiple-package shipment, a dimensional weight is simply determined by adding the individual dimensional weights for each package together.

Both TL and LTL carriers often provide discounts to hauls that serve as a roundtrip. This helps to limit empty legs by carriers and the carriers therefore often pass their savings on to customers to promote roundtrip bookings.

Accessorial charges are anticipated charges, like in-transit handling fees, fuel surcharges, and import/export charges. For each type of carrier and/or lane and/or location, accessorial charges can be defined in the PS database. After the appropriate rating is calculated for the shipment based upon the carrier, the carrier type, and any appropriate modifications required by roundtrip rating, radial rating, dimensional weighting, etc., the accessorial charges that apply are added on to the end to produce a final "expected" cost.

The PS module can schedule the shipment of small packages or small orders through parcel and express carriers (collectively hereinafter referred to as "package carriers"). Typically, package carriers use rate schedules that divide the area they service into a plurality of zones. Each zone has a set of weight breaks and associated charges. Parcel carriers typically divide the continental U.S. into several zones while

49

express carriers have one zone for the continental U.S. and one set of weight breaks and associated changes.

Package carriers generally offer several levels of service such as one-day delivery, two-delivery, normal ground, 5 and so on. The PS module during the optimization of a order batch process will consider all levels of service for a particular carrier that are relevant to meet the needs of the particular order. Some package carriers charge different rates for deliveries to commercial and residential locations. 10 These rates again will be reflected in the rate tables.

Rail carriers are very similar to TL type carriers in that they often operate seven days a week and their quoted rates (stored in the rate tables of the PS database) are typically specified in the same manners as they are with 15 respect to TL (a rate based solely on distance traveled for an entire trailer and/or rail car). As will be readily appreciated by one of ordinary skill in the art, the use of rail carriers necessarily requires posted rail schedules determine the timing of a particular freight movement rather 20 than distance and driving speeds. Additionally, the use of rail also precludes multiple stops or detours. Logically, intermodal carriers combining rail with TL carriers would necessarily incorporate all the limitations associated with TL and rail carriers. Sea carriers are similar to rail carriers 25 in the respects mentioned above.

Referring again to figure 6, it is shown the EX module's execution logic 401 performs several steps after the PS module has generated a freight plan at step 603. First, at step 604 the EX logic sends tender offers (formal requests for shipping 30 services) to the carriers selected by the PS logic during step 603. Preferably, each carrier utilized by the PS logic is electronically connected to the execution module 400 through

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the tender interface 407 such that tender offers (and subsequent acceptances or declines as described below) can be sent electronically in annotated fashion through EDI, email or the Web. Alternatively, of course, more conventional means

5   such as facsimile or telephone can be employed.

Once received, carriers can review tender offers and electronically provide an acceptance or decline (the EX monitoring this acceptance/decline communication at step 606) of the tender offer to the execution module 400 via response

10 interface 412. The EX logic can then re-route any declined orders back to the problem-solver module 300 as unexecuted orders 411 through unexecuted freight movement interface 410 for selection of a different carrier or transportation solution. As shown in the figure at 607, the EX logic decides

15 whether to send the order back to 607 for re-routing (if there is no response after a preset time or if the tender was declined) or to try re-sending the tender to the carrier (such as to give a carrier a second chance to respond to the tender).

20 Referring back to figure 6, after the EX module 401 receives confirmation that a freight movement has been completed at step 608 (preferably electronically via the shipment status interface 406 as described above with respect to figure 4) the FP module 500 receives executed orders 409

25 from the FPI 405 and the freight payment logic 501 generates freight payment invoices and accounts payable and receivable records, the operations of the freight payment logic being depicted collectively as step 609 of figure 6.

As discussed above, the freight payment ("FP") module 500

30 performs the following functions: it authenticates shipment invoices prior to payment, allocates invoiced charges to shipments and orders, compares expected charges for freight

51

movements to invoiced charges, bills customers for freight charges, authorizes payment to carriers for completed freight movements, records freight charges and sends data to attached accounting systems, and reports and analyzes freight costs.

5   The steps performed by the freight payment logic 501, collectively depicted in figure 6 as step 609, in actuality works as a series of sub-steps. Figure 8 is flow diagram that provides an overview of the sub-steps run by the FP module that make up step 609 of figure 6.

10   Order and shipment information from the EX module (or other upstream electronic execution management system) is routinely loaded at sub-step 801 into the FP module 500 and stored in the FP database 502. These automatically loaded shipment and order records can be viewed at any time by the

15 transportation planning manager 309 through the manager interface 504 at any time. These order records contain all relevant data that was utilized by the PS module 300 in preparing the cost estimate for the freight movement (for example, carrier identity, equipment type, lane, origin,

20 destination, quantity of goods, etc.) as well as data relating to when the freight movement was commenced and completed.

The re-rating sub-step 802 in figure 8 recalculates the cost of freight movements once the order records have been successfully loaded into the FP module's FP database 502. The

25 FP module's re-rate sub-process examines variables such as carrier, rates, weight, miles traveled, and accessorial charges and comes up with a cost (virtually identical in manner to that performed by the PS module and described above with respect to sub-step 704 of figure 7). It will be readily

30 understood by one of ordinary skill in the art that the FP module could be designed to either utilize the data and logic resident in the PS module to perform this calculation or could

52

alternatively essentially duplicate necessary the data and logic within its own database and logic. While the estimated cost calculated by the PS module when compiling an optimal transportation plan is typically passed to the FP module from

5   the EX module (after the associated freight movement is executed), the FP module recalculates the expected shipment cost at sub-step 802 for several reasons.

First, the estimated carrier cost is recalculated by the FP module because the carrier's expected rates and the

10 accessorial fees represented in the PS database's rate tables may have changed in the intervening period between when the shipment was routed (and thus initially rated) and when the freight movement was actually executed. Second, while the FP module as disclosed above has been discussed as part of a

15 three-module system with the PS and EX modules, the FP module as herein described can be utilized independently of one or both. In such situations wherein the FP module is used as a stand-alone freight payment management system (i.e., not in combination with the PS module and/or EX module as described

20 above) the rate tables and costing processes as described above with respect to the PS module would necessarily have to be incorporated within the FP module. Additionally, of course, there is always the chance that data may become corrupted as it is routed from the PS module.

25   In the transportation services industry carriers typically supply invoices, or bills, for completed freight movements. Traditionally, invoices were simply paper bills that were mailed from the carrier to the contracting party. According to preferred embodiments of the present invention,

30 invoices are transferred from the carrier electronically, such as via EDI, the Web, or email, and loaded into the FP module at sub-step 803 via the invoice interface 508 as shown in

figure 5. Additionally, to support carriers that do not transmit invoices electronically, invoice data can be entered into the FP module manually by the transportation planning manager 309 using manager interface 504.

5   Alternatively, of course, some transportation planning managers may prefer to use shipment status messages, or delivery notices, from carriers as the criteria by which payment of the carrier is authorized.

       Once order records have been re-rated at sub-step 802 and
10   the carrier invoices have been received, the FP module matches at sub-step 804 each re-rated order record with an associated invoice. If they can't be matched exactly (for example, if reference numbers on the record and invoice don't match or if a substantial cost difference is found between the invoiced
15   cost and the expected cost), the order and invoice pairs may be tagged for manual review or left unmatched. If a matching invoice cannot be found, the FP module will assume that it hasn't been received from the carrier and try again a preset number of times or will wait for a present amount of time
20   before generating a message for manual review.

       The freight payment module 500 attempts to match re-rated shipments to confirmed invoices before vouchering payment to the carrier at sub-step 807. For a successful match, a preset amount of various key fields must be consistent between
25   invoices and order records, such as: the bill of lading (BOL), the SCAC, ship date, weight, origin and destination.

       Once executed freight movement records are successfully matched to invoices at sub-step 804, the FP system compares the expected shipping cost (either rated initially by the PS
30   module at sub-step 704 of figure 7 or re-rated at sub-step 802 of figure 8) with the actual invoiced cost at sub-step 805, and then creates a carrier cost difference database record at

54

step 806 detailing the differences, if any, between the expected and invoiced costs. This carrier cost difference record can be used at later times by the transportation planning manager to revise the rating process such as by
5 updating accessorial charge tables or modifying carrier preference ratings (such as if a carrier's actual invoiced cost typically greatly exceed the calculated expected costs).

Additionally, a company's account department typically needs a voucher notification regarding receipt and
10 verification of an invoice such that they can cut a check to pay the carrier. Once an invoice is identified and verified in the matching sub-step 807, the FP module generates a flat file containing vouchered costs that were incurred by carriers for completed shipments, and this file is outputted (either
15 electronically or in hard copy format) to an accounts payable system at sub-step 807 through accounts payable interface 507. Shipments whose invoices are vouchered at sub-step 807 gain a status of "Vouchered" in database 502 in the FP module 500.

At sub-step 808, the FP module allocates appropriate
20 portions of the actual costs incurred by the carriers (and itemized in the carrier invoices) to the orders that comprise a particular freight movement. As will be readily appreciated by one skilled in the art, invoiced cost allocation is the process of distributing the total cost of a freight movement
25 to the shipments, orders, and/or line items that were in that freight movement. As described above, it is not uncommon for one or more orders from different clients to be combined into a single freight movement by a single carrier. Additionally, carriers often invoice a single amount for their costs. Thus,
30 it is necessary to divide the total cost of a freight movement in a fair manner among the orders that made up the freight

movement.   The FP module performs capacity allocation and linehaul factors to fairly divide costs.

Linehaul factors are used by the FP module to divide the total freight cost by legs of a trip according to various

5   groupings, including: weight, cube, pallets, distance, weight and distance, cubes and distance, pallets and distance, weight cube factor, and cost savings method. For example, if a freight movement is bearing a weight of 240 for the first leg (Shipment 1) and a weight of 160 for the second leg (Shipment

10 2), the cost is divided as follows using weight as the linehaul factor:

Total weight ("TWT") on trip = 240 + 160 = 400.

Ratio of TWT carried on first leg = 240/400 = .60

Ratio of TWT carried on second leg = 160/400 = .40

15 Due to the above allocation calculation, the first leg will be charged for 60% of the freight movement while the second leg will be charged for 40%. Cube and pallets are calculated using the same leg/total ratio method.

Distance may be combined with another factor, such as

20 weight. For linehaul allocations using weight and distance, distance is calculated either by trip mileage (actual distance traveled) or radial mileage (the sum of individual straight-line distances between origin and each stop). For example, for distance and weight linehaul allocation using a trip

25 mileage method, assume that a trip having a total cost of 1000 consists of two legs (with one order being dropped off after each leg). The first leg ending at point S1 has a distance of 200 and a weight of 500 while the second leg ending at point S2 has a distance of 400 and a weight of 900. Using the trip

30 mileage method, the distance to each end point is the total distance traveled, such that:

Distance to S1 = 200

Distance to S2 = 600 (200 to S1 + 400 to S2)

The weight distance ("WD") for each order is then calculated by multiplying the above distances to each respective end point by the weight being dropped of at that end point, such

5 that

WD of S1 = (500 weight)*(200 distance) = 100,000

WD of S2 = (900 weight)*(600 distance) = 540,000

Thus, the total weight distance is 640,000. The allocation ratios are then calculated as above with respect to the weight

10 example, such that

Allocation ratio for S1 = 100,000/640,000 = .156

Allocation ratio for S2 = 540,000/640,000 = .843

Thus, the order dropped off at S1 accrues 16% of the freight movement cost, and S2 accrues 84%. Linehauls for distance

15 combined with cube or pallets are calculated similarly.

Weight cube factor is available for linehaul allocations in the FP module and determines the following ratios:

Wt% = Order Weight/Total Weight

Cube% = Order Cube/Total Cube

20 Next, the Weight/Cube Sensitivity Factor (F) is applied. This factor is entered on the FP by the transportation planning manager and can range from zero to one. A score of 0 considers weight only, while 1 considers cube only. A ratio in between will reflect a mix of the two. The allocation

25 percentage is computed as follows:

Allocation% = W% + ((C% − W%) x F)

The allocated cost per shipment is then computed as above my multiplying the calculated allocation percentage with the total freight movement cost.

30 The cost savings linehaul factor, when utilized, causes the FP module to compute the best (standard) direct cost of all deliveries on a multi-stop trip as if they were individual

trips from the same origin point. This cost is calculated
according to the best-direct cost (i.e., based upon the best
rate each individual order could have obtained had it been
shipped individually). The ratio of an individual trip's cost

5   to the sum of all standard direct costs for these trips
together determines the allocation for that trip. For
example, if the origination point is O, and there are three
loads with one each destined for off-load points A, B, and C.
If the truck were to follow a route from O to A to B to C,

10 then the total trip distance can be represented as:
total distance = (O —> A) + (A —> B) + (B —> C)
where the notation "x -> y" represents the distance from point
x to y. The allocation ratio for each then would be:

O—>A ratio = (O—>A)/[(O —> A) + (A —> B) + (B —> C)],

15 O—>B ratio = (O—>B)/[(O —> A) + (A —> B) + (B —> C)], and

O—>C ratio = (O—>C)/[(O —> A) + (A —> B) + (B —> C)].

Again, the allocated cost for each order within the freight
movement can be calculated as detailed above from each
allocation ratio.

20   Capacity allocation breaks freight cost down by orders
and line items for a given shipment. The FP module can
perform capacity allocations according to weight, cube,
pieces, pallets, weight/cube factor, and gross sales value
ratios. For example, if shipment X has a weight of 1300, and

25 comprises only two orders, order A and order B. If order A
has a weight of 500 while order B has a weight of 800, the
weight-based capacity allocation per order is as follows:

Order A = 500/1300 = .385

Order B = 800/1300 = .615

30 Order A will be allocated 39% of the cost and Order B will be
allocated 61% of the cost. Further, if we assume that order
A, with a weight of 500, has two line items (sub orders),

58

line-item 1 (weight = 400) and line-item 2 (weight = 100) the capacity weight allocation for line-item 1 would be 80% (400/500) of the allocation for order A, while line-item 2 would be allocated the remaining 20%.

5   The weight cube factor, if specified by the transportation planning manager for capacity allocations, uses the following ratio:

Wt% = Order Weight/Total Shipment Weight

Cube% = Order Cube/Total Shipment Cube

10 The allocation percentage is computed as follows:

Allocation% = Wt% + ((Cube% - Wt%) x F)

where F is a present weight/cube sensitivity factor that varies between zero and one. The allocated cost per order is then computed as above.

15   Finally, referring again to figure 8, at sub-step 809, the FP module 500 creates an invoice record reflecting the allocated invoice cost and sends a notification to accounts receivable through the accounts receivable interface 506 (again, either electronically or in hard copy format) to

20 an accounts receivable system through accounts receivable interface 506. Optionally, at this step customer invoices interface 508 can be used to send a version of the order invoice record as a bill (electronically, faxed, printed out for sending by mail, etc.) to the customers 320. The

25 invoicing step operates similarly if the transportation planning manager needs to bill internally (such as to a sales office 318 as shown in figure 5 or to sub-divisions, etc.) for a portion of a freight movement.

One of ordinary skill in the art will appreciate that the

30 above optimization, execution and payment handling algorithms may be modified to take into account specific needs and/or problems encountered in particular industries or situations.

59

Thus, the illustrative algorithm should not be construed to limit the present invention as is claimed.

Although the present invention is preferably implemented in software, this is not a limitation of the present invention as those of ordinary skill in the art can appreciate that the present invention can be implemented in hardware or in various combinations of hardware and software, without departing from the scope of the invention. Modifications and substitutions by those of ordinary skill in the art are considered to be within the scope of the present invention, which is not to be limited except by the claims that follow.

The foregoing description of the preferred embodiments of the present invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. It will be apparent to those of ordinary skill in the art that various modifications and variations can be made to the disclosed embodiments and concepts of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided that they come within the scope of any claims and their equivalents.

The various modules, when used in combination or alone, enables statuses to be defined in database entries relating to order records and used in different ways. The transportation planning manager (system administrator) can use the manager interfaces to change status names and control how they are used by the system.

The tables below show the order and shipment status names according to one preferred embodiment of the present invention and their recommended uses. The status codes and related descriptions disclosed below in Table A1 can be modified in many ways and are disclosed below only to illustrate one useful way of utilizing such codes with the above-disclosed embodiments of the invention.

Table A1: Freight Movement status codes

Status Code	Default Status Names	Description Freight Movements
0	Routed	Initial status given to a freight movement when the problem-solver plans and selects an optimized route and then assigns a carrier to it. Orders with "Routed" status are outputted via the ROI.
T	Tendered	Indicates that a trip is in the process of being tendered to a carrier. A trip status can be set to Tendered either by the automatic status setting process by EX or by changing the status manually in the via the manger interface.
E	Re-tendered	Indicates that a TL trip was declined by a carrier and tendered to an alternate carrier.

A	Accepted	Status given to trip that was accepted by a carrier. A trip can be given this status either by the carrier response interface or by changing the status manually via the manager interface (such as where the carrier does not support EDI acceptances). The carrier response interface changes the status to Accepted when an accepted transaction is received from the carrier to which the load was tendered.
P	Dispatched	This is an optional status that can be used in various ways, depending on how a business operates. For example, it can be used to indicate that a trip was assigned to the private fleet or that it was reviewed by the transportation planning manager when the ROI output is manually reviewed before plan execution.
L	Declined	Status set by the carrier response interface when a trip was declined by all valid alternate carriers, or cannot be tendered to any more alternates. A history of Declined loads can be maintained in the EX database for carrier performance tracking purposes.
D	En-route	This status is normally given to a trip after it has departed and left the planning stage.
H	Archive	Status given a record once it is ready to be deleted or archived.

Table A2 below shows the suggested order status codes, names and their recommended use.

Table A2: Order status codes

Status Code	Default Status Name	Descriptions

N	New	Initial status given to an order when it is loaded into the system. An order with this status has not been processed by the problem-solver.
S	Scheduled	Indicates that the order is on a trip or shipment. Then the order inherits the properties of the status of the trip it is on.
U	Un-scheduled	Status given to an order when the problem-solver cannot plan a route and assign a carrier for the order. This also can be the initial order status, if desired. Scheduled orders can be unscheduled using the manager interfaces.
R	Rejected	Only orders with the status NEW can be changed to rejected. Rejected orders remain in the system but the problem-solver does not attempt to schedule them. Orders can be rejected for many reasons, including improper format and for lacking necessary order information.

Table A3 below describes events and conditions that cause status changes in a standard installation. The system administrator can use the Order Status and Freight Movement Status tabs in the Configuration userview to change status names and control how they are used. Check with the system administrator at your site to see if statuses are being used differently in your system.

Table A3: How a status changes

Reason for Status Update	Description

Automatic Status Setting	PS checks each trip and shipment built by the PS to see if certain user-defined criteria are met. If they are, the status of the trip changes to the status as dictated by the rule set by the transportation planning manager.
Carrier Response	The Carrier Response Interface changes load status values to Declined or Accepted, depending on the transaction received from the carrier.
Initial Status	Loads receive Initial status when Auto Status is not checked or criteria fails.
Manual	Transportation planning managers can set status values manually using the manager interfaces and change status action, one or many at a time. Only orders with the status NEW can be changed to rejected. An Unreject command can set the status back to New.
Routed Order	Statuses that have Update ROI Status checked will be updated to their ROI Notification status. For example, Routed becomes Tendered, Accepted become En-Route, etc..
External Freight Movement	Bills of lading that run through this process will have their statuses updated to the statuses with External Freight Movement Status checked. This allows a status to be updated by an external factor such as a warehouse shipment notification.
Stop Completed	In response to a Stop Complete event, Execution (EX) can automatically update the status of the appropriate freight movement. The Stop Complete event definition will control exactly how and when EX can update freight movement status.

64

This appendix describes the Multi-Integer

Programming ("MIP") algorithm formulations used by the PS

module in determining soft constraints in location constraint

("LC") effected optimization batch runs. The following

notation is used in the below MIP equations:

c_{it} : Cost of scheduling trip i at start time t. (Input to MIP)

u_{it} : 0 or 1 indicating if trip i is starting at time t.

v_{itk} : Unit amount that trip i starting at time t would apply to location constraint period k. Location constraint period k uniquely identifies one maximum constraint (e.g. number of weight, cube, pieces, pallets, or trips) within a time period for a specific stop activity type (e.g. pickup, delivery, setup, closedown, all combined) at a specific location. (Input to MIP)

p_k : Penalty per unit excess for location constraint period k. (Input to MIP)

q_i : Penalty for leaving trip i unscheduled. (Input to MIP)

r_i : Slack variable that indicates if a trip i is left unscheduled or not. Will be forced to zero or one since u_{it} is a binary variable. Value of 0 means trip i is schedule at some start time t. Value of 1 means trip i is not scheduled for any start time.

s_k : Slack variable that represents the unit excess for location constraint period k.

n_j : See below

l_j : Penalty for each unit of soft maximum violation variation between the adjacent location constraint periods represented by j.

SMQ_k : (SoftMaxQuantity) Maximum quantity allowed for location constraint period k

before penalty starts being applied. (Input to MIP)

HMQ$_k$: (HardMaxQuantity) Absolute maximum quantity allowed for location constraint period k. (Input to MIP)

For LC problems, u_{it}, r_i, s_k, and n_j are the variables we are solving for, all others are inputs to the MIP. The formulation attempts to minimize:

$$\sum_i \sum_t c_{it} u_{it} \quad + \quad \sum_i q_i r_i \quad + \quad \sum_k p_k s_k \quad + \quad \sum_j l_j n_j \tag{1}$$

Subject to:

$$\sum_t u_{it} + r_i = 1 \qquad \text{for each trip } i. \tag{2}$$

$$\left(\sum_i \sum_t u_{it} v_{itk} \right) - s_k \leq SMQ_k \quad \text{for each LC period } k. \tag{3}$$

$$s_a - s_b + n_j \geq 0 \qquad \text{for each directional} \tag{4}$$
pair j, of adjacent
location constraint
periods a and b.

$$s_k \geq 0 \qquad \text{for each LC period } k. \tag{5}$$

$$s_k \leq HMQ_k - SMQ_k \quad \text{for each LC period } k. \tag{6}$$

$$r_i \geq 0 \qquad \text{for each trip } i. \tag{7}$$

$$n_j \geq 0 \qquad \text{for each directional} \tag{8}$$
pair j, of adjacent
LC periods.

$$u_{it} = 0 \text{ or } 1 \qquad \text{for each trip } i \text{ and} \tag{9}$$
each start time t.

With respect to the above equations:

1. Minimize the cumulative cost of all scheduled trips, while also minimizing costs associated with location constraint violations. The cost for starting a trip at a particular time(c_{it}) will represent the actual cost incurred. The penalty for leaving a trip unscheduled will be represented

66

by q_i. If the c_{it} is greater than q_i, the MIP will benefit by not scheduling the trip at that start time. Therefore, if there is no start time for a trip whose actual cost is less than the penalty for leaving the trip unscheduled, the MIP will not even try to schedule the trip. The last part of the equation represents costs for location constraint violations. *Note: the penalty for a location constraint violation needs to be properly balanced with the penalty for leaving a trip unscheduled.*

2. No trip can be scheduled for more than one start time. Since u_{it} is a binary variable, the value of the summation of u will be either 0 or 1. A value of 0 indicates that the trip has not been assigned a start time and will force the value of r to 1. A value of 1 indicates that the trip has been assigned exactly one start time and will force the value of r to 0.

3. Forces the value of s_k to represent the unit amount by which the soft maximum for location constraint period k is being exceeded.

4. See above.

5. Prevents location constraint penalty from being applied prior to hitting the soft maximum for the constraint.

6. Prevents location constraint violations from exceeding the hard maximum.

7. Prevents the assignment of more than one start time t to a single trip i.

8. See above.

9. There is no partial assignment of a trip to a start time. A trip *i* is either assigned to start at time *t* or it is not.